A Bayesian Classifier Aided Active Contour Segmentation Model

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Abstract: Image segmentation is a significant process for the segregation of image into several regions in order to achieve the desired object or meaningful information. It is considered as the first step for any autonomous computer vision application, and for that purpose active contour models plays a vital and effective role because of its potential to detect object boundaries with the curve evolution. Various conventional approaches namely edge based, region based (global and local) have been proposed for accurate segmentation. These traditional methods perform very well on images having homogeneous intensity behavior, however it suffers on images with intensity inhomogeneity. In this paper we proposed an improved image-based hybrid energy metric by integrating Bayesian classification in conventional region growing to allow improve segmentation where current approaches suffer through degradation of gradient and intensity inhomogeneity. The quantitative results and experimental comparison validate that the proposed method performs better as compared to existing conventional approaches.

Keywords: *Active contour, Image segmentation, Bayesian classification, Region based segmentation, Local and global region based segmentation, Intensity inhomogeneity, Hybrid energy*

1. Introduction

Image segmentation is fine strategy of segregation an image into multiple regions in order to achieve desired and meaningful results from image. It has extensive importance in image processing and computer vision application [1]. The imperfect acquisition of image leads the image towards intensity inhomogeneity and that can cause issue for perfect image segmentation. Due to presence of intensity variations researchers and doctors get difficulty to generate true segmentation results. Therefore, to overcome these problems various methods for image segmentation have applied [2]. And for that purpose active contour models [3] are absolutely effective and constructive.

Active contour or snakes are the model that plays a vital role to create a frame work for getting outline and contour the image to find the desired object features. In contemporary computer vision and image analysis the active contour are used to detect the feature of interest in image such as boundaries, lines, and edges. And for that the evolution of curve is regulated by energy function as expressed in Eq.(1)

$$\int_0^1 E_{int}(C_s) + E_{ext}(C_s) + E_{cons}\ (C_s)\ ds \qquad (1)$$

Where E_{int} represents the internal energy, C_s is snake or curve, E_{ext} is a external force and E_{cons} shows as external constraint force [4]. The present active contour model can be classified as; edge based models [4,5] and region based models [1,3].

The gradient of image considered as most extensive factor in edge based models to evolve the curve. Edge based models usually suffers to achieve desired segmentation results having images with noisy or weak edges. Instead, region based model evolves the contour by utilizing inside and outside curve information. Thereby the performance of region based model as compared to edge based is better and capable on noisy and weak edge images [6].

The classification of region based models can be into global [7,8] and local [9,10] region based segmentation. Images that homogeneous in nature are performed better by global region based method which are basically based on Mumford, Shah and Chan, Vese [3,7]. These global method normally figure out the intensity variation for the complete image. And small changes among the particular regions cannot be handle by these methods [11]. However, in local method[10,12] the small intensity changing which occurs between background and foreground examined efficiently. Moreover, local based region methods are very effective for images having intensity difference in certain regions, But this is not always the case. Periodically it also constraints due to intensity inhomogeneity.

These conventional image segmentation approaches has certain limitation as we discussed. Therefore, in order to improve image segmentation this research proposed Bayesian classifier aided solution. The Bayesian classifier approach is very beneficial because of its prior knowledge usage regarding the under study circumstances for image analysis and interpretation. Bayesian analysis based on the posterior likeliness and expectations which summarize the amount of one's sureness regard the situation. The

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posterior probability is correlative to the product of likelihood and prior probability. Information which is contained in the new data encircle by the likelihood.
The description of Bayesian classification theorem are as follows:
Classes in Bayesian classification represents with (k). values for different classes (C) shows from 1 . . . k. $P(C_k)$ is the prior probability of class k. Input data may denoted by X. To achieve Bayesian classification the posterior probability my figure out as $P(C_k|x)$,for classes k . Furthermore classifying X by allow with class having highest posterior probability[12]. Bayesian classification theorem have been showed in Eq.(2)

$$P(C_k|x) = \frac{P(x|C_k)P(C_k)}{P(x)}$$

$$= \frac{P(x|C_k)P(C_k)}{\sum_k P(x|C_k)P(C_k)} \quad (2)$$

The rest of this paper is organized as follows, the main focus of Section 2 is on the related work. The methodology followed in this paper has been outlined in section 3. Section 4 reports the discussions and results of this research followed by a conclusion in Section 5.

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2. Related Work

In image analysis domain a lot of research work has been conducted assisted by active contour on image segmentation techniques. Moreover, the different techniques and approaches implemented by the researchers to improve the accuracy of model and framework for achieve the required results. In [4], describes that active contour models or snakes are energy minimization system which are controlled by superficial obstruct forces. furthermore, It is a supervised progression under the impact of image forces and external controlled forces which are used to build model for the detection of image feature is based on gradient of image. In [3] this research different models are introduced to detect objects from an image based on the techniques of curve evolution, functional for segmentation and level set. The model is able to detect the contours both with or without gradient, provide solutions for detection for small and distinct object and features in image, also labeling of initial curve can be placed anywhere in the image. The main objective of this paper [14], to proposed a hybrid active contour model to overcome the limitations such as shows less efficiency to segment the images having weak border line. It will be formed by alternating the edge information into region based level with harmonic mean based signed pressured force function. this model performs better in segmentation of image, and desired features having noise, Because of both region and edge information. The image registration method in [15] introduced which is based on stable shape features and recommended the stable region with set of rotation, rate of homogenous features, in order to achieve the matching areas assisted by the multi-scale image segmentation. Research taken in [16] with the help of Bayesian classification open source urban land data analyzed. The utilization of urban land result, classification of urban land cover, progress towards the framework classification of building types. Random Forest implemented for segment ground objects for the classification of urban land cover. Prior building information acquired by open source map assist to drive Fuzzy Decision Tree from the Bayesian model for differentiate the buildings from other human made objects. Study has been done in [17] for image segmentation aided with simple clustering methods as K-means and fuzzy C-means. After preprocessing cluster based initialization utilized for this purpose. Furthermore, extracted feature incorporated in existing cluster methods for desired segmentation. In [18] the novel training approach of the Bayesian classifier has been proposed for images of skin segmentation. The system was based on video analysis, And to separate the foreground pixel of human skin image from the background, the implementing approach is based on naïve Bayesian classifier. For the preparation of training dataset the novel approach is proposed through which the normalization influence related to the size of the foreground area is avoided with the consideration of unique color from each image.

3. Methodology

This section addresses the methodology of this research. The main stages used in this image segmentation process involves raw data collection, preprocessing, analyzes conventional region based image segmentation methods, Moreover, proposed Bayesian counterpart to enhance existing conventional segmentation methods, final segmentation. The methodology of this proposed research has been shown in fig (1). These stages are further elaborating in successive section.

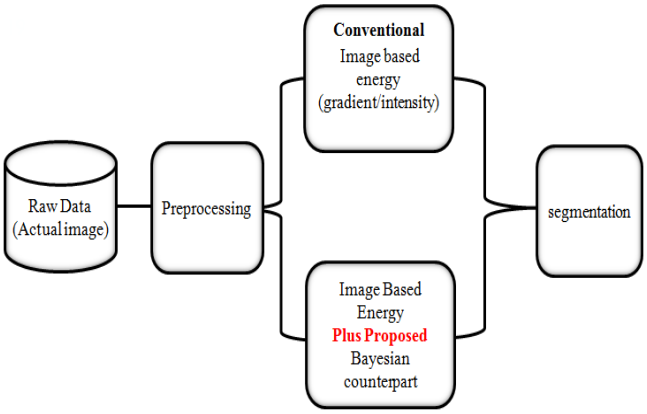


Figure.1. Research Methodology

3.1 Raw data

The large number of synthetic images dataset has been acquired in order to accomplish the active contour image segmentation. These images have the attributes of intensity inhomogeneity. In recent past years such type of images having intensity variation are most in demand to address by most researchers. We are showing few intensity inhomogeneous images from our utilized dataset in fig.(2)

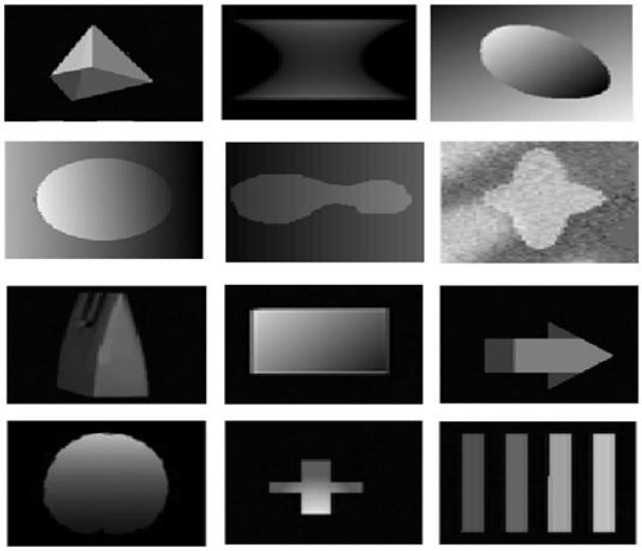


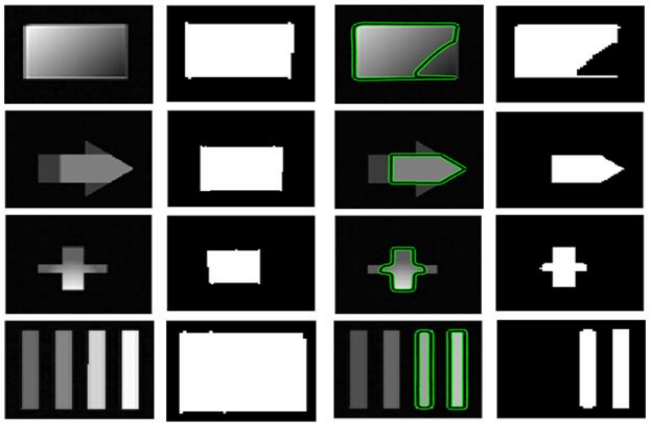
Figure.2. Intensity Inhomogeneous Images

3.2 Preprocessing

The imperfect acquisition of images causes the noise and distortion in image. Therefore, in order to enhance or improve the quality of image preprocessing is an very important and effective step before processing the image [19]. Initially dataset contain 120 images, After resizing and removing distortion from images background to foreground we were able to utilize 100 images for this image segmentation research.

3.3 Analyzes Conventional Method

In existing region based segmentation our main focus to work within localized segmentation rather than global. Because in most cases localized region based segmentation works better as compared to global region based segmentation[20], However, this is not always the case there is also some limitation of local based segmentation approach while dealing with gradient variation images which we are showing below in fig.(3).

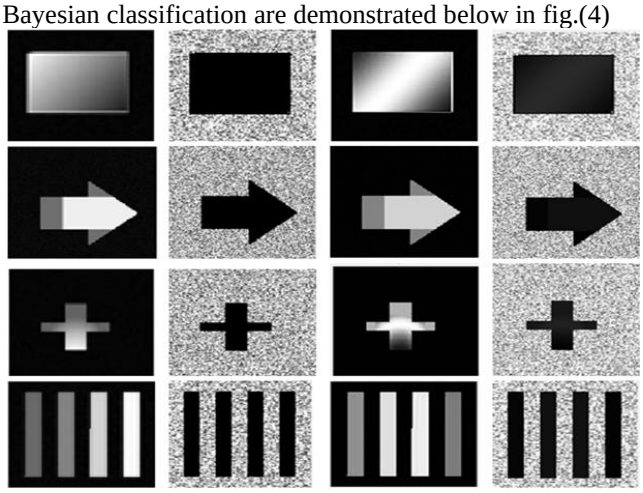


(a) (b) (c) (d)

Figure.3.(a) Actual image (b) Initial mask (c) Incomplete Contour (d) Conventional Local segmentation

3.4 Proposed Bayesian Classification

As a result of traditional localized failure we proposed Bayesian classification aided active contour segmentation energy model incorporated with present local based method. The finite availability of data in image cannot solve the problem, Therefore Bayesian classifier assist to separates the background information from the foreground in a form of separate probabilistic classes. The achieved probability difference and additional information from Bayesian classification are demonstrated below in fig.(4)

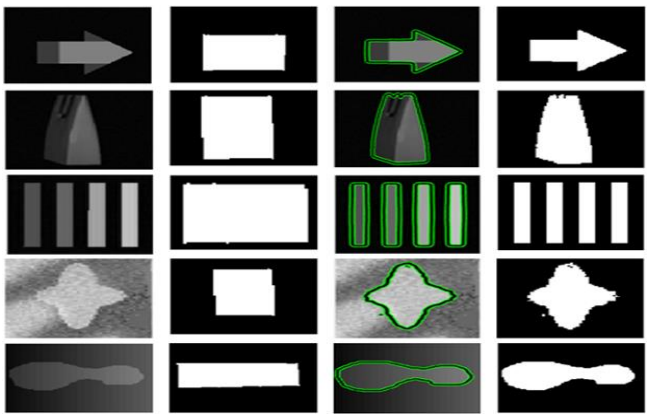


(a) (b) (c) (d)

Figure.4. (a) Actual image (b) Background Separation (c) Foreground Separation (d) Bayesian Probability Difference

3.5 Final Segmentation

As we showed traditional local based method limitations on intensity degradation in Fig.(3). Ultimately with the utilization of collected information from Bayesian probabilistic classes showed in fig.(4) we have generate an additional energy metric, then incorporate with existing local region based segmentation. Our proposed improved hybrid energy metric accomplishes the task for desired image segmentation where traditional segmentations methods suffers. The final segmentation which is achieved by our proposed method have been showing in Fig.(5).

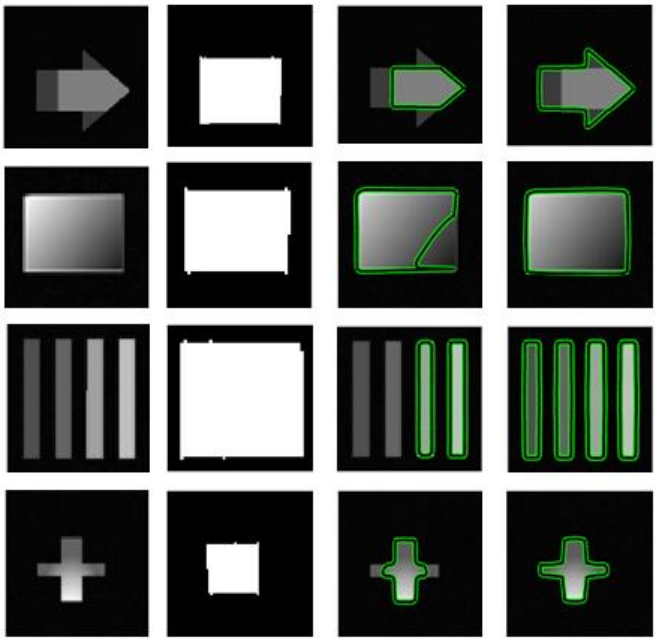


(a) (b) (c) (d)

Figure.5. (a) Actual image (b) Initial mask (c) Complete Contour (d) Proposed Segmentation

4. Results And Discussion

This section presents the tests and experimental comparisons of Bayesian classification approach used in this research. The diversified range of intensity inhomogeneous synthetic images have been used in MATLAB tool for the enhancement of contemporary segmentation techniques. The available dataset tested on both traditional and proposed method. Furthermore, the final segmentation results compared with used local region based method and our proposed Bayesian classification active contour segmentation model. It is evident that our proposed energy metric fulfill the assignment on given intensity variation synthetic image dataset for improve image segmentation. The comparison of these methods have been shown in Fig.(6).

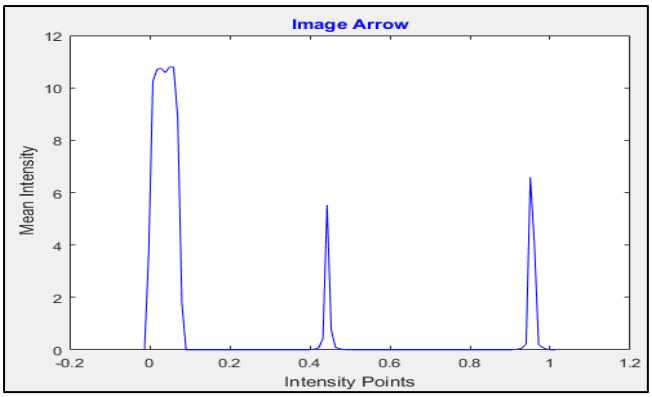


(a) (b) (c) (d)

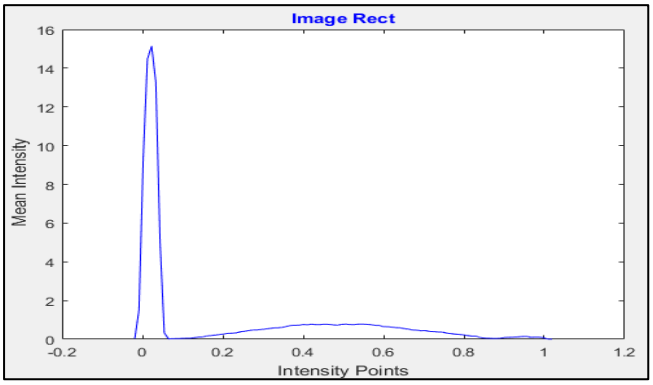
Figure.6. (a) Actual image (b) Initial mask (c) Traditional localized failure (d) Proposed method success

4.1 Graphical Representation of Intensity Variation

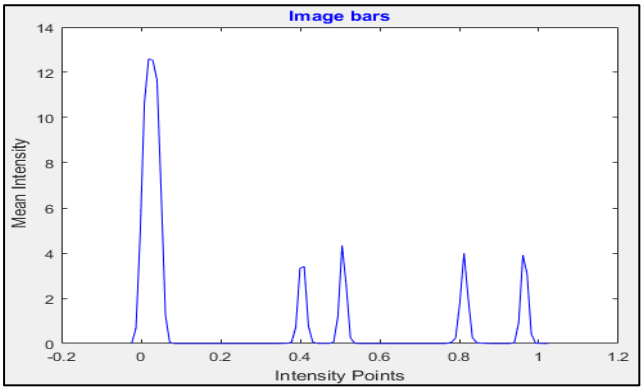
In section 4. Results And Discussion we demonstrated few intensity inhomogeneity images. Thus, in this section we are showing graphical representation of intensity variation for images utilized in Figure.6(a) which refers the deviation of gradient by representing the sudden change of peaks from low to high and vice versa. Moreover, to understand the deviation and degradation of gradient efficiently at every point of image the intensity variation graphs have been shown in Fig.(7).



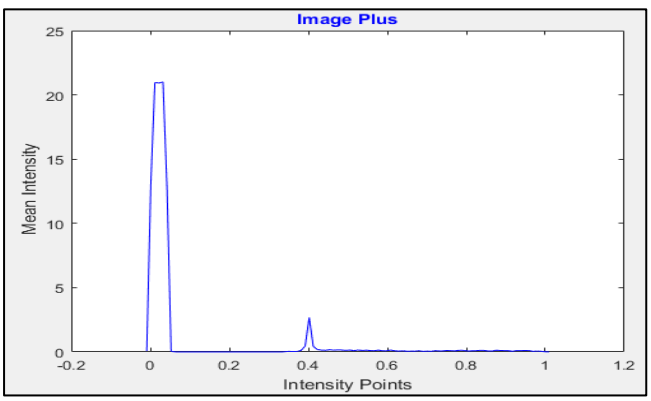
(a) Intensity Graphs of Image Arrow



(b) Intensity Graphs of Image Rect



(c) Intensity Graphs of Image Bars



(d) Intensity Graphs of Image Plus

Figure.7. Graphical Representation of Intensity Variation

4.2 Performance Evaluation

To understand the efficiency of quantitative results which have achieved by both conventional and proposed image segmentation methods was implemented by using MATLAB. Moreover, the results generated by our proposed Bayesian classification active contour segmentation model analyzed with traditional local region based method. The comparison of these quantification are based on the information about Accuracy, sensitivity, precision, specificity, F-measure, Jaccard.

Accuracy: It is achieved by the ratio of similar segmented pixels to the total number of pixels.

$$\text{Accuracy} = \frac{(TP+TN)}{(TP+FP+TN+FN)} * 100 \quad (3)$$

Sensitivity: It describes the similarity of test is return positive in favor of given features. It is calculated as:

$$\text{sensitivity} = \frac{TP}{(TP+TN} \quad (4)$$

Specificity: It is the correlation of test that is return negative in favor of given features. It is calculated as:

$$\text{specificity} = \frac{TN}{TN+FP} \quad (5)$$

Precision: It is the ratio between correctly predicted true positive pixels to the total predicted positive pixels. It is calculated as:

$$\text{Precision} = \frac{TP}{TP+FP} \quad (6)$$

Recall: It is the ratio between the correctly predicted positive pixels to the total number of positive instances. It is calculated as:

$$\text{Recall} = \frac{Tp}{P} \quad (7)$$

Dice: It describes the two times intersection of segmented results with the ground truth then divided by sum of all.

$$\text{Dice} = \frac{2(A \cap B)}{A+B} \quad (8)$$

Jaccard: It is the ratio between the intersection and union of segmented result and ground truth.

$$\text{Jaccard} = \frac{A \cap B}{A \cup B} \quad (9)$$

The comparative analysis and performance evaluation have been showed in Table.1.

Table.1. Performance comparison of segmentation method

Performance measures	Methods	Image Arrow	Image Rect	Image Bars	Image Plus
Accuracy	Local Segmentation	0.9303	0.9204	0.7719	0.9816
	Proposed Method	0.9899	0.9845	0.9837	0.9938
Sensitivity	Local Segmentation	0.6624	0.8040	0.4337	0.8094
	Proposed Method	0.9940	0.9691	0.8413	0.9567
Specificity	Local Segmentation	0.9967	0.9941	0.9937	0.9987
	Proposed Method	0.9890	0.9943	0.9940	0.9973
Precision	Local Segmentation	0.9771	0.9885	0.9886	0.9832
	Proposed Method	0.9507	0.9908	0.9889	0.9720
F-measure	Local Segmentation	78.95%	88.62%	60.50%	88.52%
	Proposed Method	**97.18%**	**97.98%**	**91.38%**	**96.43%**
Jaccard	Local Segmentation	65.22%	79.66%	43.37%	79.40%
	Proposed Method	**94.52%**	**96.05%**	**84.13%**	**93.11%**

From Table.1. It is evident that from conventional image segmentation approaches the performance of our proposed Bayesian classification active contour method is more better, accurate and efficient on our provided dataset. To evaluate the efficiency of image segmentation the main focus is always on Jaccard index and F-Measure. It is showed in Table.1. that Jaccard index of our proposed method for images [Arrow (94.52%), Rect (96.02%), Bars (84.13%), Plus (93.11%)] And F-Measure of our Proposed method for images [Arrow (97.18%), Rect (97.18%), Bars (91.38%), Plus (96.33%)] respectively, are more accurate than traditional local segmentation.

5. Conclusion

In this paper we presented enhanced image-based hybrid energy model integrated by Bayesian Classification for conventional region-based methods in order to fulfill the desired image segmentation where existing region-based methods stuck through intensity inhomogeneity. Therefore, we utilized numerous synthetic intensity inhomogeneous image dataset for that purpose. The main contribution of this research was to proposed the additional energy function that assist the current region-based approach for improved and successful segmentation. The comparative analysis showed that our Bayesian classifier aided active contour segmentation model perform better than previous region-based method and gives successful results on our given dataset.

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